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FINAL TECHNICAL REPORT

for

NASA Grant NSG-7546

Participation in the Mars Data Analysis Program: Global and Regional Studies of Wind-Indicators on the Surface of Mars.

(National Aeronautics and Space Administration)

Principal Investigator: Professor Joseph Veverka
Co-Investigator: Dr. Peter Thomas

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Prepared by:

J. Veverka, Principal Investigator

A comprehensive study of global and regional patterns on Mars inferred from surface eolian features (wind streaks, dune deposits, etc.) visible in Viking Orbiter images has been completed. Major results of the study are summarized in the Ph.D. dissertation of S. Lee, "Eolian Sediment Transport on Mars: Seasonal and Topographic Effects" (the Abstract of this dissertation is reproduced in Appendix 1) and in more than a dozen publications in journals such as Icarus and the Journal of Geophysical Research (see Appendix 2 for a complete bibliography).

A major effort involved precise measurements of the dimensions of topographic obstacles (craters, hills, ridges) on Mars, as well as of their associated wind streaks, to determine how the aerodynamic shape of an obstacle affects near-surface airflow on the planet. The findings are summarized in Lee (1984a).

A classification of Martian wind streaks was developed on the basis of albedo contrast and the presence or absence of either topographic obstacles or sediment deposits at the point of origin of the wind streaks (Thomas et al., 1981). Veverka et al. (1981) discussed these question of why some Martian craters produce depositional wind streaks, while others produce erosional ones. They concluded that local meteorological conditions (specifically the degree of stability of the atmospheric boundary layer) play a major determinant role. The scheme, which explains available observations extremely well, is summarized in Table 1.

TABLE I

	Dust storm		Non-Dust storm	
	Equatorial	Nonequatorial	Equatorial	Nonequatorial
Conditions	1. Dust fallout 2. Stable atmosphere 3. Coherent wind directions	1. Less dust 2. Intermediate stability 3. Extremely variable wind directions	1. No dust fallout 2. Low wind velocity 3. Atmosphere unstable only near subsolar point	1. No dust fallout 2. High winds in southern hemisphere decreasing toward low latitudes 3. Atmosphere unstable near subsolar latitude
Bright streaks	Blocking of flow allows deposition of dust *forming bright streaks.*	Lesser amounts of dust and variable wind direction prevent formation of bright streaks.	Lack of dust and lack of blocking prevent bright-streak formation.	Lack of dust and highly unstable atmosphere (in places) prevents formation of bright streaks.
Dark streaks	Dust fallout and stability of atmosphere prevent erosion. No dark streaks form.	Wind velocity too low and stability too high to promote erosional-streak formation.	Low wind velocities and modestly stable atmosphere prevent erosion. No dark streaks form.	Winds high enough and atmosphere unstable enough for *formation of erosional streaks*, but only in small latitude band.

Why do some craters on Mars produce depositional wind streaks, while others produce erosional ones? There is no evidence to suggest that crater morphology or topography plays the determining role. Some craters can form either type of streak at different times of the Martian year, suggesting that the controlling factor is meteorological. We propose that atmospheric stability is the determining factor: a stable atmosphere should lead to blocking of the wind flow by crater rims producing wind shadows over distances comparable to those of observed bright streaks. Such conditions should prevail in a belt about the equator at the time of major dust storms. As the atmosphere becomes more transparent following the end of the dust storms, the rate of surface heating increases and the stability of the atmosphere is reduced. Under such conditions, blocking is not expected. Flow over obstacles results in increased surface stress downwind, conditions which encourage the formation of erosional dark streaks. These ideas are shown to be consistent with the seasons at which erosional and depositional streaks are formed, as well as with their distribution on the planet. Specifically, the scheme explains why craters which have both erosional and depositional streaks occur only within a very restricted latitude belt.

Appendix 1

Abstract of Ph.D. Dissertation by S. Lee

EOLIAN SEDIMENT TRANSPORT ON MARS: SEASONAL AND TOPOGRAPHIC EFFECTS

Steven Wendell Lee, Ph.D.
Cornell University 1984

Since the time of the earliest telescopic observations, Mars has been known to exhibit distinct bright and dark surface features which vary on a seasonal and year-to-year basis. In 1971 and 1972, the Mariner 9 orbiter returned images of numerous albedo features across the face of the planet. These "wind streaks" were observed to generally form in association with craters, and were inferred to be indicative of either erosion or deposition of bright dust. Between 1976 and 1980, the Viking Orbiter missions provided thousands of high-resolution images of these features, allowing their seasonal and temporal behavior to be monitored throughout the course of three martian years. This study uses Viking images to map, at high resolution and with frequent time coverage, the occurrence of wind streaks in several regions. The direction of regional dust transport over the time span of the observations is inferred from streak orientations. Combined with previous spacecraft observations and the Earth-based record, the long-term effects of eolian activity in a region can be evaluated. Correlation of streak patterns with

regional topography and geology allows the relative effects of surface properties, topography, and surface elevation on eolian transport to be evaluated. The patterns, as viewed over several years, reveal the effects of seasonal variations in atmospheric dust loading and wind directions on albedo features. Finally, a statistical study of wind streaks is included to evaluate the relationship between the size of obstacles and the type and size of associated streaks. The main results of these studies are: (1) Wind streaks form in association with a wide range of obstacle sizes, with small obstacles producing streaks more effectively than do large ones. (2) Seasonal variations in martian albedo features arise from changes in the deposition rate from the atmospheric dust load, and are primarily controlled by the occurrence and extent of yearly dust storm activity. (3) In regions of significant slopes, downslope winds completely dominate the global atmospheric circulation, effectively sweeping dust from the surface even at the lowest atmospheric pressures existing on the planet. (4) The eolian activity documented during the Viking missions is representative of that which has occurred over the long-term history of the planet.

Appendix 2

Bibliography of Publications Supported by this Grant

Lee, S., P. Thomas, and J. Veverka (1980). Slope winds in Tharsis--Viking observations over a martian year. Bull. Am. Astro. Soc. 12, 725.

Lee, S. W., and P. C. Thomas (1980). Near surface flow of volcanic gases on Io. Icarus 44, 280-290.

Lee, S., P. Thomas, and J. Veverka (1981). Comparison of eolian activity in the Elysium and Tharsis regions of Mars. NASA-TM 84211, 222-224.

Lee, S. W. (1981). Aeolian activity in Tharsis--Viking Orbiter observations over a martian year. Mem. S.A. It., 439-443.

Lee, S., P. Thomas, and J. Veverka (1981). Phobos, Deimos, and the Moon: Comparison of crater ejecta patterns. NASA TM-84211, 105-107.

Lee, S., P. Thomas, and J. Veverka (1981). Phobos, Deimos, and the Moon: Comparison of crater ejecta patterns. Bull. Am. Astro. Soc. 13, 710.

Lee, S. W., P. C. Thomas, and J. Veverka (1982). Wind streaks in Tharsis and Elysium: Implications for sediment transport by slope winds. J. Geophys. Res. 87, 10025-10041.

Lee, S. W., P. Thomas, and J. Veverka (1982). Mars: Influence of obstacle type and size on wind streak production. NASA TM-85127, 188-190.

Lee, S. W., P. Thomas, and J. Veverka (1982). Mars: Influence of obstacle type and size on wind streak production. Bull. Am. Astro. Soc. 14, 757.

Lee, S. (1983). Seasonal and secular observation of martian albedo features: Spacecraft observations over six martian years. Bull. Am. Astro. Soc. 15, 845.

Lee, S. W. (1984a). Mars: Wind streak production as related to obstacle type and size. Icarus 57, 339-357.

Lee, S. W. (1984b). Eolian sediment transport on Mars: Seasonal and topographic effects. Ph.D. Dissertation. Cornell University, Ithaca, New York.

Thomas, P. Present wind activity on Mars: Relation to large latitudinally zoned sediment deposits. J. Geophys. Res. 87, 9999-10,008.

Thomas, P., J. Veverka, S. Lee, and A. Bloom (1981). Classification of wind streaks on Mars. Icarus 45, 124-153.

Thomas, P., and J. Veverka (1979). Seasonal and secular variation of wind streaks on Mars: An analysis of Mariner 9 and Viking data. J. Geophys. Res. 84, 8131-8146.

Veverka, J., P. Gierasch, and P. Thomas (1981). Wind streaks on Mars: Meteorological control of occurrence and mode of formation. Icarus 45, 154-166.